DEPARTMENT OF MECHANICAL ENGINEERING

M. Tech. in Mechanical Engineering (Design) – Course Structure

Brief Description: M. Tech. in Mechanical Engineering (Design) plays a vital role in the field of Mechanical Engineering discipline from the fundamentals to applications in industrial/Defence practices. The importance of this program is vivid from understanding basics, design, development and implementation of mechanical system.

The objective of entire program is to impart knowledge to Engineers/ Scientists pertaining to Mechanical system design from the basics of engineering to final machine or equipment design ready to use in engineering system. This can be achieved by teaching a candidate different range of subjects for enhancing their analytical skills related to Machine design. Other objective of the program is to produce quality design engineers to cater to the needs of the relevant industry. The programme is conducted by well-versed faculty, invited experts from reputed institutions and industries.

Eligibility:

1. The eligibility for the postgraduate programme will be B.E./B. Tech degree and AMIE qualified engineers in Mechanical/Production Engineering disciplines from recognized university.
2. This programme is open for civilian GATE qualified candidates, DRDO Scientists/Officers and Officers from Tri-services. This programme is also open to foreign nationals from the countries approved by GOI.

Organization: M. Tech Mechanical Engineering with specialisation in Design is a four-semester programme. In the first semester there are six courses and one lab, in second semester, there are seven courses and in the third semester there are two electives. In each of these semesters, there will be three tests and a final semester examination for every course. In third semester in addition to two courses a M. Tech. (phase I) dissertation is there and in fourth semester, only dissertation work is to be completed. Half yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester, student submits a thesis and makes a presentation about the M. Tech. project, which is evaluated by the Internal and External examiners.

The details of the courses offered are:

Semester- I

S. No.	Course Code	Course	Contact Hours/week			Credits
			L	T	P	
1	AM 602	Mathematical Modeling and System Analysis	3	0	0	3
2	AM 607	Mathematics for Engineers	3	0	0	3
3	ME 602	Advanced Mechanics of Materials	3	0	0	3
4	ME 603	Advanced Fluid & Thermal Engineering	3	0	0	3
5	ME 619	Tribology for Design	3	0	0	3
6	ME 631	Product Design and Development	3	0	0	3
7	ME 606	ME Laboratory	0	0	4	2
		Total	**18**	0	**4**	**20**

Semester- II

S. No.	Course Code	Course	Contact hours/week			Credits
			L	T	P	
1	ME 607	Computational Fluid Dynamics	3	0	0	3
2	ME 608	Finite Element Methods	3	0	0	3
3	ME 609	Mechanical Vibrations	3	0	0	3
4	ME 630	Design of Machinery	3	0	0	3
5		Elective – I	3	0	0	3
6		Elective – II	3	0	0	3
7	TM 649	Scientific/Engg. Practices and Skills	3	0	0	3
		Total	**21**	**0**	**0**	**21**

* 02 week industrial practice school during summer vacation for scholarship students.

Semester- III

S. No.	Course Code	Course	Contact Hours /week			Credits
			L	T	P	
1		Elective – III	3	0	0	3
2		Elective – IV	3	0	0	3
3	ME 651	M.Tech. Dissertation Phase I	16			8
		Total	**22**			**14**

Semester-IV

S. No.	Course Code	Course	Contact Hours /week			Credits
			L	T	P	
1	ME 652	M.Tech. Dissertation Phase II	28			14
		Total	**28**			**14**

List of Electives (3 credits)

S. No.	Course Code	Course Name
Elective I, II, III & IV		
1	AM 603	Operations Research
2	ME 604	Advanced Materials and processing
3	ME 611	Design for manufacturability
4	ME 617	Kinematics and dynamics of Machinery
5	ME 618	Composite Structures
6	ME 627	Fatigue, Fracture and Failure Analysis
7	ME 628	Design of Hydraulic and Pneumatic systems
8	ME 629	Design of Experiments
9	ME 632	Design Optimization
10	ME 633	Mechanical behavior of materials
11	ME 634	Experimental Stress Analysis
12	ME 635	CAD/CAM
13	ME 636	MEMS: Design, Fabrication and Characterization
14	ME 637	Design of Pressure Vessels
15	ME 650	Mini – Project #

Shall be offered in 3rd Semester only.

AM 602: Mathematical Modelling and System Analysis (SEM I)

(Pre requisite: Basic knowledge of calculus & Differential Equations) Mathematical Modelling: Introduction to modelling and simulation, Classification of systems into continuous and discrete, Structural characterization of mathematical model and validation techniques. Modelling Techniques: Dimensional analysis: Concept behind dimensional approach, Buckingham Pi theorem, Models using dimensional approach. Continuous approach: Models based on physical laws. Discrete Approach: Models based on discrete approach. Prey - Predator models. Combat Modelling: Modelling the Lanchester laws with System Dynamics.

System Analysis: The state of a system, mathematical models of continuous linear lumped parameter, time invariant systems, Discrete time systems, Linear approximation of non-linear systems, Topological models of system, Block diagram representation, Signal flow graph, and Mason's rule. A generalized approach to modelling. Principles of conservation and continuity and Applications. Basics of simulator technology.

Text/References:

1. Modelling Mathematical Methods & Scientific Computations, 1995, Nicola Bellomo & Luigi Preziosi, CRC Press.
2. Systems Modelling and Analysis, 2003, I.J. Nagrath, M. Gopal, Tata McGraw Hill, New Delhi.
3. Introduction to Mathematical Systems Theory - A behavioural approach, 2nd Ed., 2008, Jan Willen Polderman, Jan C. Willems, Springer.
4. Introduction to System Dynamics, 1967, J.L. Shearer, A.T. Murphy, H.H. Richardson, Addison & Wesley.
5. Introduction to System Analysis, 1985, T.H. Glisson, McGraw Hill.

AM 607: Mathematics for Engineers (SEM I)

Linear Algebra: General (real) vector spaces, Subspaces, Linear independence, Dimension, Norms, Orthogonal bases and Gram-Schmidt orthogonalization.

Principles of floating point computations and rounding errors.

Systems of Linear Equations: factorization methods, pivoting and scaling, residual error correction method.

Iterative methods: Jacobi, Gauss-Seidel methods with convergence analysis, Conjugate gradient methods.

Nonlinear systems: Newton and Newton like methods.

Interpolation: review of Lagrange interpolation techniques, Newton interpolation, piecewise linear, cubic splines and Bezier curves, error estimates.

Approximation: uniform approximation by polynomials, data fitting and least squares approximation.

Numerical differentiation and integration: Differentiation and integration by interpolation, adaptive quadratures and Gaussian quadrature.

Initial Value Problems for Ordinary Differential Equations: Euler, Modified Euler, Runge - Kutta methods, multi - step methods, predictor and corrector methods, stability and convergence analysis.

Two Point Boundary Value Problems: finite difference methods with convergence results.

Solution of PDE: Parabolic, Hyperbolic and Elliptic Equations using finite difference method.

Text/References

1. Linear Algebra and its Applications, 4th Ed., 2008, Gilbert Strang, Academic Press.
2. Applied Linear Algebra and Matrix Analysis, 2007, Thomas S Shores, Springer.
3. Numerical Analysis, 9th Ed., 2010, Richard L. Burden, J. Douglas Faires, Brooks/Cole.
4. An Introduction to Numerical Analysis, 2nd Ed. 2008, Kendall E. Atkinson, John Wiley & Sons.
5. Elementary Numerical Analysis - An Algorithm Approach, 3rd Ed, 2008, Samuel D Conte and Carl de Boor, McGraw Hill.
6. Numerical Methods for Scientific and Engineering Computation, 6th Ed., 2012, M. K. Jain, S.R.K. Iyengar, R.K. Jain, New Age International Ltd.
7. Numerical Solutions of Partial Differential Equations: An Introduction, 2nd Ed., 2005, K. W. Morton, D. F. Mayers, Cambridge University Press.
8. Scientific Computing and Differential Equations: An Introduction to Numerical Methods, 2nd Ed. 1992, Gene H. Golub, J. M. Ortega, Academic Press.
9. Numerical Computation in Science and Engineering, 2nd Ed., 2008, G. Pozrikidis, Oxford University Press.

ME 602: Advanced Mechanics of Materials (SEM I)

Theory of Elasticity

Introduction, Stress. Differential equations of equilibrium, strain, compatibility conditions, plane problems of elasticity, stress strain relations, stress functions and applications in 2D problems. Pressurized cylinders & rotating disks, Governing equations, Stresses in thick walled cylinder under internal and external pressures. Introduction to experimental stress analysis.

Energy Methods

Work done by forces and strain energy, reciprocal relations, Castigliano's theorems, Fictitious load method, statically indeterminate structures, theorem of virtual work, generalization of castigliano's theorem.

Asymmetrical Bending of beams

Bending of prismatic bars and unsymmetrical bending. Concept of shear centre in symmetric and un-symmetric bending, Plate bending, bending of curved beams.

Torsion of non-circular sections

Introduction, torsion of general prismatic solid section like circular, elliptical, rectangular, triangular shafts, membrane analogy, torsion of thin walled tubes, torsion of thin walled multiple cell closed sections.

Text/References:

1. Theory of Elasticity, 1970, Timoshenko SN & GoodierJN, McGraw Hill.
2. Advanced Mechanics of Materials, 2nd Ed., 1998 Cook RD & Yound WC, Prentice Hall.
3. Advanced Mechanics of Materials, 5th Ed., 1995 Boresi AP, Sidebottom OM, John Wiley.
4. Experimental Stress Analysis, 3rd Ed., 2005, Dally JW & Riley WF, College House Enterprises.

ME 603: Advanced Fluid & Thermal Engineering (SEM I)

Review of concepts in kinematics of Fluid Motion, Vorticity, Circulation, Velocity potential and Stream function. Basic laws in Integral Form, Momentum Theorem, Applications in Propulsion, Energy equations, Applications. Dynamics of Ideal Fluid Motion,

Applications, Integration of Euler's equations of motion. Governing Equations of fluid flow in differential form, Navier-Stokes Equations and exact solutions, Energy Equation and solution of fluid flow with thermal effects. Dimensional Analysis. Prandtl's Boundary Layer equations, Laminar Boundary Layer over a Flat Plate, Blausius solution. Turbulent flows in two-dimensional channels and pipes, Velocity field, Smooth and Rough pipes, Drag reduction in pipes, Turbulent Boundary Layer over a Flat Plate, Laws of wall over Flat Plates, Effect of Pressure gradient, Boundary Layer control.

Advanced topics in conduction and convection heat transfer, solution to laminar and turbulent convective heat transfer problems, external and internal flows, free and forced convection.

Text/References:

1. Viscous Fluid Flow, 2005, F. M. White, McGraw-Hill.
2. Convective Heat and Mass Transfer 4th Ed., 2004, W. M. Kays, M. E. Crawford and B. Weigand, McGraw-Hill.
3. Heat Transfer, 10th Ed., 2009, J P Holman, McGraw-Hill.
4. Boundary Layer Theory, 8th ed, 2000, Herrmann Schlichting, Springer
5. Heat and Mass Transfer, 2nd ed 1963, Eckert ERG and Drake RM (translated by J P Gross), McGraw-Hill Inc. US

ME 619: Tribology for Design (SEM I)

Introduction:

Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket - Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing, Terminology - Sliding contact bearings -Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings

Friction and Wear:

Friction - Laws of friction - Friction classification - Causes of Friction, Theories of Dry Friction, Friction Measurement, Stick-Slip Motion and Friction Instabilities, Wear - Wear classification - Wear between solids – Wear between solid and liquid - Factors affecting wear – Measurement of wear, Theories of Wear, Approaches to Friction Control and Wear Prevention

Lubrication of Bearings:

Mechanics of Fluid Flow - Theory of hydrodynamic lubrication -Mechanism of pressure development in oil film, Two Dimensional Reynolds's Equation and its Limitations, Idealized Bearings, Infinitely Long Plane Fixed Sliders, Infinitely Long Plane Pivoted Sliders, Infinitely Long Journal Bearings, Infinitely Short Journal Bearings, Designing Journal Bearing - Sommerfeld number – Raimondi and Boyd method - Petroff's Solution - Parameters of bearing design - Unit pressure - Temperature rise - Length to diameter ratio - Radial clearance - Minimum oil-film thickness.

Hydrodynamic Thrust Bearing:

Introduction - Flat plate thrust bearing - Tilting pad thrust bearing, Pressure Equation - Flat plate thrust bearing - Tilting pad thrust bearing, Load - Flat plate thrust bearing - Tilting pad thrust bearing, Center of Pressure - Flat plate thrust bearing - Tilting pad thrust bearing, Friction - Flat plate thrust bearing - Tilting pad thrust bearing

Hydrostatic and Squeeze Film Lubrication:

Hydrostatic Lubrication - Basic concept - Advantages and limitations - Viscous flow through rectangular slot – Load carrying capacity and flow requirement - Energy losses - Optimum design, Squeeze Film Lubrication - Basic concept - Squeeze action between circular and rectangular plates - Squeeze action under variable and alternating loads, Application to journal bearings, Piston Pin Lubrications.

Elasto-Hydrodynamic Lubrication:

Principles and Applications, Pressure viscosity term in Reynolds's equation, Hertz's Theory, Ertel-Grubin equation, Lubrication of spheres, Gear teeth bearings, Rolling element bearings.

Gas (Air-) Lubricated Bearings:

Introduction, Merits, Demerits and Applications, Tilting pad bearings, Magnetic recording, discs with flying head, Hydrostatic bearings with air lubrication, Hydrodynamic bearings with air lubrication, Thrust bearings with air lubrication.

Tribological Aspects of Rolling Motion:

The mechanics of tyre-road interactions, Road grip and rolling resistance, Tribological aspects of wheel on rail contact.

Finite Bearings:

Hydrostatic bearings, Hydrodynamic bearings, Thrust oil bearings, Porous Bearings, Foil bearings, Heat in bearings.

Text/ References:

1. A. Harnoy " Bearing Design in Machinery "Marcel Dekker Inc,NewYork,2003
2. M.M.Khonsari & E.R.Booser, " Applied Tribology", John Willey &Sons,New York,2001
3. E.P.Bowden and Tabor.D.," Friction and Lubrication", Heinemann EducationalBooks Ltd., 1974.
4. A.Cameron, "Basic Lubrication theory ", Longman, U.K.., 1981.
5. M.J.Neale (Editor), "Tribology Handbook ", Newnes. Butter worth, Heinemann, U.K., 1995.

ME 631: Product Design And Development (SEM I)

Introduction: Significance of product design, product design and development process, sequential engineering design method, the challenges of product development,

Product Planning and Project Selection: Identifying opportunities, evaluate and prioritize projects, allocation of resources Identifying Customer Needs: Interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs.,

Product Specifications: Establish target specifications, setting final specifications, Concept Generation: Activities of concept generation, clarifying problem, search both internally and externally, explore the output,

Industrial Design: Assessing need for industrial design, industrial design process, management, assessing quality of industrial design,

Concept Selection: Overview, concept screening and concept scoring, methods of selection.

Theory of inventive problem solving (TRIZ): Fundamentals, methods and techniques, General Theory of Innovation and TRIZ, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas

Concept Testing: Elements of testing: qualitative and quantitative methods including survey, measurement of customers' response.

Intellectual Property: Elements and outline, patenting procedures, claim procedure,

Design for Environment: Impact, regulations from government, ISO system.,

Text books and references:

1. Ulrich K. T, and Eppinger S.D, Product Design and Development, Tata McGraw Hill
2. Otto K, and Wood K, Product Design, Pearson
3. Engineering of creativity: introduction to TRIZ methodology of inventive Problem

Solving, By Semyon D. Savransky, CRC Press.

4. Inventive thinking through TRIZ: a practical guide, By Michael A. Orloff, Springer
5. Systematic innovation: an introduction to TRIZ ; (theory of inventive Problem Solving), By John Terninko, Alla Zusman, CRC Press.

ME 607: Computational Fluid Dynamics (CFD) (SEM-II)

Basic of Computational Fluid Dynamics. Governing Equations of fluid mechanics and heat transfer, physical boundary conditions, basic aspects of Discretization. Finite Difference and Finite Volume formulation of steady/transient one-dimensional conduction equation., Finite Volume formulation of steady one- dimensional convection and diffusion problems, Solution algorithms for pressure-velocity coupling in steady and unsteady flows. discretization equations for two dimensional convection and diffusion. Numerical methods for the Navier-Stokes equation. Turbulence models: mixing length model, Two equation (k-epsilon) models – Grid generation. Practical's on CFD software (FLUENT).

Text/References

1. An introduction to Computational Fluid Dynamics, 2nd edition, 2007, HK Versteeg & W Malalasekera, Pearson Education.
2. Introduction to Computational Fluid Dynamics, 2005, Anil W Date, Cambridge University Press, NY, USA.
3. Computational Fluid Dynamics & Heat Transfer, 1984, Anderson, Dale A, John C Tanehill and Richard H Pletcher, McGraw Hill.
4. Numerical Heat Transfer and Fluid Flow, 1980, Patankar SV, Hemisphere, New York.

ME 608: Finite Element Methods (SEM-II)

Prerequisites to FEM

Application of FEM, Strain- displacement relations, Stress-strain relations, Differential equations of equilibrium, Co-ordinates, basic element shapes, interpolation function, Minimum potential energy. Properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics.

1-D structural problems

Analysis of axial Bar element - stiffness matrix, load vector, temperature effects, Quadratic shape function.

Analysis of Trusses- Plane Truss elements, Transformation matrix, stiffness matrix, load vector

Analysis of Beams - Hermite shape functions – beam stiffness matrix - Load vector - Problems

2-D stress analysis using CST

Plane stress, Plane strain, Force terms, Stiffness matrix and load vector, boundary conditions. Axisymmetric body subjected to axisymmetric loading-Numerical problems, Isoparametric element - quadrilateral element, linear shape functions.

Scalar field problems

1-D Heat conduction through composite walls, fins of uniform cross section,
2-D heat conduction problems, Torsional problems.

Dynamic considerations:

Dynamic equations - consistent mass matrix – Eigen values, Eigen vector, natural frequencies - mode shapes - modal analysis.

3-D problems:

Tetrahedron element - Jacobian matrix - Stiffness matrix, CAD softwares and its applications, Brief description to analysis of Plates & Shells.

Text Books/References

1. "Introduction to Finite Elements in Engineering", Tirupathi R.Chandrupatla and Ashok D. Belagundu, Pearson Education (Singapore) Pte Ltd, 2006.
2. "An Introduction to Finite Element Methods", J.N. Reddy, Tata Mc Graw Hill, 2008.
3. A First Course in the Finite Element Method by Daryl L. Logan.
4. "Concepts and Applications of Finite Element Analysis", Robert Cook, Wiley India, Pvt., Ltd., 4th Edition-2007.
5. "An Introduction to Finite Element Methods", J.N. Reddy, Tata Mc Graw Hill, 2008.
6. "Finite Element Procedures", K.J. Bathe, PHI Learning, 2009.
7. The Finite Element Methods in Engineering / SS Rao / Pergamon.

ME 609: Mechanical Vibrations (SEM-II)

Single Degree of Freedom Systems: Free and forced vibrations of damped and undamped systems; Simple harmonic excitation; steady state response; torsional vibrations.

Vibration of Systems with Two Degrees of Freedom: Free and forced vibration of spring-mass-damper systems; torsional vibrations; modal analysis of undamped and damped systems; numerical methods: Matrix iteration, Holzer's method, Dunkerley's lower and Rayleigh's upper bound approximations; Dynamic vibration absorbers

Vibration of Multi-degree of Freedom and Continuous Systems: Vibrating string; Longitudinal and torsional vibration of rods; Free and forced vibration of beams; Properties

of vibrating systems: Flexibility and stiffness influence coefficients; Reciprocity theorem; Eigenvalue analysis; Orthogonality of eigenvectors; Modal matrix

Experimental methods in vibration analysis: Vibration instruments: exciters, transducers, analysers, measurement devices: vibrometers, velocity meters and accelerometers; Signal analysis techniques: time domain analysis, frequency domain analysis, amplitude and power spectra, coherence, auto and cross correlations, amplitude and frequency modulations; Tests for free and forced vibrations

Case studies: Vehicle dynamics: introduction to nonlinear and random vibrations, vehicle subjected to random vibrations (for example an uneven road); Fluid-structure interaction problems: vibration of suspension bridges

Text Books:

1. "Introductory Course on Theory and Practice of Mechanical Vibrations", J.S.Rao, K.Gupta, Revised second edition, New Age International Publishers
2. "Theory of Vibration with Applications", William T. Thomson, Marie Dillon Dahleh, Pearson Low Price Edition.
3. Mechanical Vibrations, J.B.K. Das & P.L.S.Murthy, Sapna book house.

Reference Books:

1. Principles and Techniques of Vibrations, Leonard Meirovich, Prentice Hall Inc.
2. Engineering Vibration, DJ Inman, Prentice Hall International Inc.
3. "Mechanical Vibration and Shock Measurements", J.T.Broch, Bruel and Kjae Publication.
4. "Applications of Random Vibrations", N. C. Nigam, S. Narayanan, Narosa Publishers.

ME 630: Design of Machinery (SEM-II)

Introduction: Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, Mobility – Kutzbach criterion, Gruebler"s criterion – Grashof"s Law – Kinematic inversions of four-bar chain and slider crank chains – Limit positions – Mechanical advantage – Transmission Angle – Description of some common mechanisms – Quick return mechanisms, Straight line generators, Universal Joint – rocker mechanisms.
Kinematics of mechanisms/machineries: Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method– Velocity and acceleration polygons – Velocity analysis using instantaneous centres – kinematic analysis of simple mechanisms – Coincident points – Coriolis component of Acceleration – Introduction to linkage synthesis problem.
Dynamics of mechanisms/machineries:
Dynamics Fundamentals, Dynamic Force Analysis, Balancing, Engine Dynamics, Multi cylinder Engines.

Kinematic and dynamic analysis of machine components: Classification of cams and followers – Terminology and definitions – Displacement diagrams –Uniform velocity, parabolic, simple harmonic and cycloidal motions – Derivatives of follower motions – Layout of plate cam profiles – Specified contour cams – Circular arc and tangent cams – Pressure angle and undercutting – sizing of cams.
Law of toothed gearing – Involutes and cycloidal tooth profiles –Spur Gear terminology and definitions –Gear tooth action – contact ratio – Interference and undercutting. Helical, Bevel, Worm, Rack and Pinion gears [Basics only]. Gear trains – Speed ratio, train value – Parallel axis gear trains – Epicyclic Gear Trains.

Outcomes:

Upon completion of this course, the students can able to apply fundamentals of mechanism/machines for the design of new mechanisms/machines and analyse them for optimum design.

Text books:

1. R L Norton, "Design of Machineries", 5th Edition, McGraw Hill Publishers.

References:

1. Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms", 3rd Edition, Oxford University Press, 2009.
2. Rattan, S.S, "Theory of Machines", 3rd Edition, Tata McGraw-Hill, 2009.
3. Thomas Bevan, "Theory of Machines", 3rd Edition, CBS Publishers and Distributors, 2005.
4. Cleghorn. W. L, "Mechanisms of Machines", Oxford University Press, 2005.
5. Allen S. Hall Jr., "Kinematics and Linkage Design", Prentice Hall, 1961.
6. Ghosh. A and Mallick, A.K., "Theory of Mechanisms and Machines", Affiliated East West Pvt. Ltd., New Delhi, 1988.
7. Rao.J.S. and Dukkipati.R.V. "Mechanisms and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.

ELECTIVES

AM 603: Operations Research

Introduction to OR, Linear programming (Simplex Method, Revised Simplex Method, Dual simplex, Duality theory), Transportation Models, Integer linear Programming, Dynamic Programming, Introduction to Game Theory. Classical optimization techniques, one dimensional nonlinear optimization, Unconstrained optimization using calculus (Taylor's theorem, convex functions, Coercive functions). Unconstrained optimization via iterative methods (Newton's method, Gradient/ conjugate gradient based methods, Quasi- Newton methods). Constrained optimization (Penalty methods, Lagrange multipliers, Kuhn-Tucker conditions). Genetic Algorithms. Note: Relevant practicals to be taught while teaching module.

Text/References

1. Operations Research: An Introduction, 9th Ed., 2010, Taha, H.A., Prentice Hall of India.
2. Optimization Theory and Applications, 2nd Ed., 1984, S.S. Rao, Wieley Eastern Ltd.

3. Engineering Optimization: Theory and Practice, 4th Ed., 2009, S.S. Rao, Wieley Eastern Ltd.
4. Optimization: Theory and Practice, 2004, MC Joshi, KM Moudgalya, Narosa.
5. Introduction to Optimization, 1988, Beale, John Wiley.

ME 604: Advanced Materials and Processing

Introduction of advanced materials and its manufacturing processes for engineering applications.

Piezoelectric materials (PZT): Piezoelectric effect, Di-electric hysterisis, piezoelectric constants, piezoelectric charge constants, dynamic behaviour of PZT transducers, piezoelectric materials and manufacturing techniques (stability, poling and depolarisation).

Shape memory alloys (SMA): Shape memory effect and the metallurgical phenomenon of SMA, Temperature assisted shape memory effect, Visco-elastic behaviour, magnetic shape memory effect. Various shape memory alloys. Manufacturing technology of SMAs.

Electro rheological (ER) and magneto-rheological (MR) materials: Characteristics of ER and EM fluids. ER and EM materials.

Composite materials: Design and manufacturing of polymer matrix, metal matrix and ceramic matrix composites. Various forms and type of reinforcements, fillers and additives.Design of composites for structural, wear resistance and high temperature applications.

Micro-electro-mechanical (MEMS) systems: Introduction, characteristics of silicon wafers and other materials for MEMS applications. Various manufacturing techniques of MEMS components Materials for high temperature applications - Ni-Cr alloys, ODS materials, Ni base and Co based super alloys, carbon-carbon composites.

Powder metallurgy: Introduction and feature of powder metallurgy processes. Advanced solidification techniques: directional solidification, single crystal growth and levitation melting.

Advanced Material processing techniques: Thermal spraying, Ion beam machining, Laser and Electron beam processing, Friction Stir Welding, Special alloys machining, Superplastic forming, Flow forming, Explosive forming, Thin films and their deposition, Diamond coating techniques-tribological applications, Diffusion bond coating of high temperature materials.

Texts/References:

1. Gandhi, M.V. and Thompson, B.S., Smart materials and Structures, Chapman and Hall, 1992.
2. Otsuka, K. and Wayman, C. M., Shape memory materials, C.U.P, 1998
3. Taylor, W., Pizoelectricity, George Gorden and Breach Sc. Pub., 1985
4. Mallick, P.K., Fiber Reinforced Composites Materials, Manufacturing and Design Marcel Dekker Inc, New York, 1993.
5. William D Callister: Materials Science and Engineering: An Introduction, 6th Edition, Wiley Publication.
6. S. Kalpakjian and S. Schmid: Manufacturing Engineering and Technology, 4th Edition, Pearson Education.
7. M. P. Grover: Fundamentals of Modern Manufacturing: Materials, Processes &Systems , Prentice Hall.

ME 611: Design for Manufacturability

Manufacturing Considerations in Design: Design for manufacture, Tolerencing and tolerance analysis. Processing techniques and limitations for metals, polymers and ceramics. Influence of materials in processing and tooling on the design of components. Finishing, surface coatings and surface modifications of materials.

Engineering Design: Design of cast, forged, sheet metal parts and welded constructions. Design for assembly and dismantling, modular constructions. Erection, operation, inspection and maintenance considerations, Ergonomics.

Machining considerations: Design for accuracy, locating pins and registers, machining in assembly, adjustment. Backlash and clearance adjustment. Examples illustrating the various principles. Available design variants for some of the common basic functional requirements.

Text /References*:*

1 Ashby, M. F. "Materials Selection in Mechanical Design", Pergaman Press, 1992.
2 Bralla J., "Handbook of Product Design for Manufacture", McGraw Hill, 1988.
3 Levy S., and Dubois, L. H, "Plastics Production Design Engineering Handbook, Methuen Inc., 1985.
4 Dieter G E, Engineering Desing, McGraw-Hill, 1991.
5 Yotaro Hatamura, The Practice of Machine Design, Claredon Press Oxfor, 1999.
6 Ertas Atilia and Jones J C, The Engineering Design Process, John Wiley & Sons, 1996.
7 Waldron B M and Kenneth J W, Mechanical Design: Theory and Methodology, Spriinger, 1996.

ME 617: Kinematics and Dynamics of Machinery

Machine kinematics: Overview, Degrees of freedom, Links and joints, Grashof condition, 4-bar linkage, slider-crank, and inverted slider crank

Machine Dynamics: Newtonian solution method, Force analysis of linkage, Shaking force and torque, Balancing linkage, Flywheels

Gears and gear trains: Terminologies of gears and gear trains, Interface, undercutting, contact ratio, Simple gears and compound gear trains, Planetary gear trains

Cam systems: Cam terminologies, Cam function design and sizing

Programmable mechanisms: Introduction to industrial manipulators, Kinematic chains and classifications, Coordinate transformation, Forward and inverse kinematics

Text/References:

1. R. L. Norton, *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines*, McGraw-Hill, current edition.

ME 618: Composite Structures

Introduction composite materials

Classification and characteristics, mechanical behavior of composite materials, basic terminology, and manufacture of laminated fiber-reinforced composite materials, current and potential advantages of fiber –reinforced composite materials, applications of composite materials.

Macromechanical behavior of lamina

Introduction, stress-strain relations for anisotropic materials, stiffnesses, compliances , and engineering constants for orthotropic materials, restrictions on engineering constants, stress train relation for plane stress in an orthopic material, stress-train relations for lamina of arbitrary orientation, invariant properties of an orthotropic lamina, strengths of an orthographic lamina, biaxial strength criteria for an orthotropic lamina.

Micromechanica behavior of lamina

Introduction, mechanics of materials approach to stiffness, elasticity approach to stiffness, comparison of approaches to stiffness, mechanics of materials approach to strength.

Macromechanical behavior of laminates

Introduction, Classical Lamination Theory, Special Cases Of Laminate Stiffness, Theoretical Versus Measured Stiffness, Strength Of Laminates, Inter-Laminar Stress.

Introduction to design of composites structures

Introduction to structural design, material selection, configuration selection, laminate joints design requirements and design failure criteria, optimization concepts, design analysis philosophy for composite structures.

Fabrication methods of composites structures

Introduction to Various Fabrication Methods, VARTM And RFI Methods, Process Parameters In VARTM Method, Permeability Measurements, VARTM Process Model, Process Parameters Of RFI Method Film Casting And Characteristics, Concepts Of VARTM and RFI Process Optimisation.

Testing and characterisation of composites

Lamina strength characterization, tensile testing, compression testing, in-plane shear testing, short beam test, double cantilever beam test. Physical properties characteristion void content evaluation, fibre Volume Fraction Evaluation, DMA, DSC FOR Tg, Wet Properties Of Lamina, NDE Methods, Ultrasonic A-scan and CT-Scan Methods For Chracteristion Of Composites.

Text books:

1. Mechanics of composite materials, by Robert. M. Jones, second sedition, Taylor and Francis,1999.

2. Experimental chracteristion of advanced composites materials, third edition, Donald f Adams, Lief A. Carlsson and R. Byron pipes. CRC press.

Reference books:

1. Mechanics of fibrous composites by carl. T. Herakovich-john wiley and sons, 1997.55
2. Advanced composite materials, Lalit Gupta, Himalayan books. New delhi, 1998
3. Liquid moulding technologies, c d Rudd, a c long, k n Kendall and c g e Mangin, woodhead publishing limited, Cambridge England.
4. Process modeling in composites manufacturing, Suresh g advani, e. Murat sozer, Marcel Dekker, inc.

ME 627: Fatigue, Fracture and Failure Analysis

FATIGUE OF STRUCTURES:

S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.

STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR:

Low cycle and high cycle fatigue - Coffin - Manson's relation - Transition life - cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner's theory - Other theories.

PHYSICAL ASPECTS OF FATIGUE:

Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.

FRACTURE MECHANICS:

Strength of cracked bodies - Potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - stress analysis of cracked bodies - Effect of thickness on fracture toughness - stress intensity factors for typical geometries.

FATIGUE DESIGN ANDTESTINIG:

Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.

TEXT BOOKS

Prasanth Kumar – "Elements of fracture mechanics" – Wheeter publication, 1999.
Barrois W, Ripely, E.L., "Fatigue of aircraft structure", Pe/gamon press. Oxford, 1983.

REFERENCES

1. Sin, C.G., "Mechanics of fracture" Vol. I, Sijthoff and w Noordhoff International

Publishing Co., Netherlands, 1989.
2. Knott, J.F., "Fundamentals of Fracture Mechanics", Buterworth & Co., Ltd., London, 1983.

ME 628: Design of Hydraulic and Pneumatic Systems

Hydraulic System & Components

Sources of Hydraulic Power: Pumping theory – Pump classification – Gear pump, Vane Pump, piston pump, construction and working of pumps – pump performance – Variable displacement pumps. Fluid Power Actuators: Linear hydraulic actuators – Types of hydraulic cylinders – Single acting, Double acting special cylinders like tanden, Rodless, Telescopic, Cushioning mechanism, Construction of double acting cylinder, Rotary actuators – Fluid motors, Gear, Vane and Piston motors

Design of Hydraulic Circuits

Construction of Control Components : Director control valve – 3/2 way valve – 4/2 way valve – Shuttle valve – check valve – pressure control valve – pressure reducing valve, sequence valve, Flow control valve – Fixed and adjustable, electrical control solenoid valves, Relays, ladder diagram. Accumulators and Intensifiers: Types of accumulators – Accumulators circuits, sizing of accumulators, intensifier – Applications of Intensifier – Intensifier circuit.

Pneumatic Systems and Components

Pneumatic Components: Properties of air – Compressors – Filter, Regulator, and Lubricator Unit – Air control valves, Quick exhaust valves, and pneumatic actuators. Fluid Power Circuit Design, Speed control circuits, synchronizing circuit, Penumo hydraulic circuit, Sequential circuit design for simple applications using cascade method.

Design of Pneumatic Circuits

Servo systems – Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves. Fluidics – Introduction to fluidic devices, simple circuits, Introduction to Electro Hydraulic Pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits; failure and troubleshooting.

Text Books:

1. Anthony Esposito, "Fluid Power with Applications", Pearson Education 2000.
2. Majumdar S.R., "Oil Hydraulics", Tata McGraw-Hill, 2000.
3. Johnson, James L., Introduction to Fluid Power, Delmar Publishers, 2003

References:

4. Majumdar S.R., "Pneumatic systems – Principles and maintenance", Tata McGraw Hill, 1995

5. Harry L. Stevart D.B, "Practical guide to fluid power", Taraoeala sons and Port Ltd. Broadey, 1976.

6. Michael J, Prinches and Ashby J. G, "Power Hydraulics", Prentice Hall, 1989.

7. Dudelyt, A. Pease and John T. Pippenger, "Basic Fluid Power", Prentice Hall, 1987.

ME 629: Design of Experiments

Overview and Basic Principles, Simple Designs and Analysis of Variance, Block Designs, Latin Squares and Related Designs, Full Factorial Designs, 2-level Full Factorial and Fractional Factorial Designs, Response surface methods and designs, Designs with Random Factors, Nested Designs, and split-plot Designs

Text/ References:

1. Clewer, A.G. and D.H. Scarisbrick. 2001. Practical Statistics and Experimental Design for Plant and Crop Science. John Wiley and Sons, LTD. New York Morris, T.R. 1999.

2. Experimental Design and Analysis in Animal Sciences. CABI Publishing, New York

ME 632: Design Optimization

Unit I

Introduction

Design Characteristics of Mechanical Elements - Adequate and Optimum design - Principles of optimization - Conventional Vs Optimal design process - Design variables - Formulation of objective function – Design constraints - Variable bounds - Classification of Engineering optimization problem**.**

Unit II

Single Variable Optimization Techniques

Optimality Criteria - Bracketing Methods - Exhaustive search method - Bounding phase method – Region Elimination Methods - Interval halving method - Fibonacci search method - Golden section search method - Gradient based Methods - Newton - Raphson method - Bisection method - Secant method - Cubic search method.

Unit III

Multi Variable and Constrained Optimization Techniques

Optimality criteria - Direct search Method - Simplex search methods - Hooke-Jeeve's pattern search method - Powell's conjugate direction method - Gradient based method - Cauchy's method - Newton's method - Conjugate gradient method. Kuhn - Tucker conditions - Penalty Function - Concept of Lagrangian multiplier - Complex search method - Random search method

Unit IV

Intelligent Optimization Techniques

Introduction to Intelligent Optimization - Soft Computing - Working principles of Genetic Algorithm Types of
reproduction operators, crossover & mutation, - Simulated Annealing Algorithm - Particle Swarm Optimization
(PSO) - Graph Grammer Approach - Example Problems

Unit V
Engineering Applications
Structural applications - Design of simple truss members. Design applications - Optimum design of simple axial, transverse loaded members - Optimum design of shafts - Optimum design of springs. Dynamic applications - Optimum design of single, two degree of freedom systems and gear vibration absorbers. Mechanisms applications - Optimum design of simple linkage mechanisms

References

1. Jasbir S Arora, *Introduction to Optimum design,* Mechrawhill International, 2011.
2. S. S.Rao, *Engineering Optimisation: Theory and Practice*, Wiley- Interscience, 2008.
3. K. Deb, *Optimization for Engineering design algorithms and Examples*, Prentice Hall of India Pvt. 2005.
4. C.J. Ray, *Optimum Design of Mechanical Elements,* Wiley, John & Sons, 2007.
5. R.Saravanan, *Manufacturing optimization through intelligent techniques*, Taylor & Francis Publications.

ME 633: Mechanical Behavior of Materials

Introduction to deformation behaviour: Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress – strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of yield strength in metals and ceramics.

Elasticity Theory: The State of Stress and strain, stress and strain tensor, tensor transformation, principal stress and strain, elastic stress-strain relation, anisotropy, elastic behaviour of metals, ceramics and polymers.

Yielding and Plastic Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, flow rules, strain hardening, Ramberg- Osgood equation, stress - strain relation in plasticity, plastic deformation of metals and polymers

Microscopic view of plastic deformation: crystals and defects, classification of defects, thermodynamics of defects, geometry of dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation

movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals - Hall-Petch and other hardening mechanisms, grain size effect - source limited plasticity, Hall- Petch breakdown, dislocations in ceramics and glasses.

Fracture: fracture in ceramics, polymers and metals, different types of fractures in metals, fracture mechanics – Linear fracture mechanics -KIC, elasto-plastic fracture mechanics - JIC, Measurement and ASTM standards, Design based on fracture mechanics, effect of environment, effect of microstructure on KIC and JIC, application of fracture mechanics in the design of metals, ceramics and polymers.

Deformation under cyclic load - Fatigue: S-N curves, Low and high cycle fatigue, Life cycle prediction, Fatigue in metals, ceramics and polymers.

Deformation at High temperature: Time dependent deformation - creep, different stages of creep, creep and stress rupture, creep mechanisms and creep mechanism maps, creep under multi-axial loading, microstructural aspects of creep and design of creep resistant alloys, high temperature deformation of ceramics and polymers

Text/References:

1.J. Roesler, H. Harders,and M. Baeker,"Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers, and Composites", Springer- Verlag, 2007.
2. W.K. Liu, E.G. Karpov, H.S. Park, "Nano Mechanics and Materials", John Wiley and Sons Pvt. Ltd, 2006.
3. Thomas H. Courtney, "Mechanical Behavior of Materials", McGraw-Hill, 1990.

ME 634 : Experimental Stress Analysis

Measurements & Extensometer

Principles of measurements, Accuracy, Sensitivity and range of measurements. Mechanical, Optical Acoustical and Electrical extensometers and their uses, Advantages and disadvantages.

Electrical Resistance Strain Gauges

Principle of operation and requirements, Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross sensitivity, Rosette analysis, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators.

Photoelasticity

Two dimensional photo elasticity, Concept of light – photoelastic effects, stress optic law, Interpretation of fringe pattern, Compensation and separation techniques, Photo elastic materials. Introduction to three dimensional photo elasticity.

Brittle Coating and Moire Methods

Introduction to Moire techniques, brittle coating methods and holography.

Non – Destructive Testing

Fundamentals of N DT, Radiography, ultrasonic, magnetic particle inspection, Fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique.

Text Books

1. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata McGraw-Hill, New Delhi, 1984.

References:

1. Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw-Hill Inc., New York, 2005, IV edition.

2. Hetyenyi, M., "Hand book of Experimental Stress Analysis", John Wiley and Sons Inc., New York, 1972.

3. Pollock A.A., "Acoustic Emission in Acoustics and Vibration Progress", Ed. Stephens R.W.B., Chapman and Hall, 1993

ME 635 : CAD/CAM

Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives. 2D & 3D Geometric Transformations: Translation, Scaling, Rotation, Reflection and Shearing, concatenation. Graphics standards: 302 KS IGES, PDES. Wire frame modeling: Curves: Curve representation. Analytic curves – lines, Circles, Ellipse, Conis. Synthetic curves – Cubic, Bezier, B-Spline, NURBS. Surface entities, Surface Representation. Analytic Surface – Plane Surface, Ruled Surface, Surface of Revolution, Tabulated Cyliner. Synthetic Surface-Cubic, Bezier, Bspline, Coons. Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial – Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG). Feature Based Modeling, Assembling Modeling, Behavioural Modeling, Conceptual Design & Top Down Design. Capabilities of Modeling & Analysis Packages such as solid works, Unigraphics, Ansys, Hypermesh. Computer Aided Design of mechanical parts and Interference Detection by Motion analysis.

Text/Reference:

1. CAD/CAM: Computer-Aided Design and Manufacturing by M Groover and E. Zimmers, Pearson Education, 1983.
2. CAD/CAM in Practice by A J Medland, Springer science and media, 2012

ME 636: MEMS - Design, Fabrication, and Characterization

MEMS: Fabrication:

Conventional MEMS fabrication using VLSI technology: lithography, chemical etching: isotropic and anisotropic, Plasma etching, reactive ion etching (RIE), oxidation, chemical vapour deposition (CVD), LPCVD, PECVD, surface micromachining, LIGA, single layer and higher layer fabrication. Non-conventional MEMS fabrication: laser micromachining and welding, processing of metals and nonmetals with laser, Electro Discharge and Electro Chemical micromachining (EDM and ECM), Microstereolithography: scanning process, dynamic mask process. Electronic packaging.

MEMS: Design and Analysis:

Basic concepts of design of MEMS devices and processes, Design for fabrication, Other design considerations, Analysis of MEMS devices, FEM and Multiphysics analysis, Modeling and simulation, connection between molecular and continuum mechanics, MEM system level analysis from perspective of control theory.

MEMS: Characterization:

Technologies for MEMS characterization, Scanning Probe Microscopy (SPM): Atomic Force, Microscopy (AFM), Scanning tunnelling microscopy (STM), Magnetic Force Microscopy, Scanning Electron Microscope, Laser Doppler vibrometer, Electronic Speckle Interference Pattern technology (ESPI). Examples and case studies: Comb actuator for nanopositioning stage by POLYMUMPS process

Texts/References:

1. Nadim Maluf, "An Introduction to Microelectromechanical Systems Engineering," Artech House, Boston, 2000.
2. Stephen D. Senturia, "Microsystems Design," Kluwer Academic Publishers, New York, November 2000
3. S. M. Sze, "VLSI Technology," McGraw-Hill International Editions, Singapore, 1988.
4. M.Elwenspoek and H. Jansen, "Silicon Micromachining," Cambridge University Press, Cambridge, UK, 1998.
5. Norio Taniguchi, editor "Nanotechnology," Oxford University Press, Oxford, UK, 2003.
6. Joseph McGeough, editor "Micromachining of Engineering Materials," Marcel Dekker, Inc., New York, 2002.
7. Marc Madou, "Fundamentals of Microfabrication: The science of miniaturization," CRC Press, LLC, 2002.

ME 637 : Design Of Pressure Vessel

Introduction

Methods for determining stresses – Terminology and Ligament Efficiency – Applications.

Stresses in Pressure Vessels

Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.

Design of Vessels

Design of Tall cylindrical self-supporting process columns –Supports for short, vertical and horizontal vessels – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design. Introduction to ASME pressure vessel codes

Buckling Of Vessels

Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

Text/References:

1. John F. Harvey, Theory and Design of Pressure Vessels, CBS Publishers and Distributors, 1987.
2. Henry H. Bedner, "Pressure Vessels, Design Hand Book, CBS publishers and Distributors, 1987.
3. Stanley, M. Wales, "Chemical process equipment, selection and Design. Buterworths series in Chemical Engineering, 1988.
4. William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Pre ASME Pressure Vessels and Piping Conference, 1997

ME 650: Mini Project